AN2056
APPLICATION NOTE

Extension of the SRC DiSEcQ 1 standard for control of Satellite Channel Router based one-cable LNBs

1 System overview

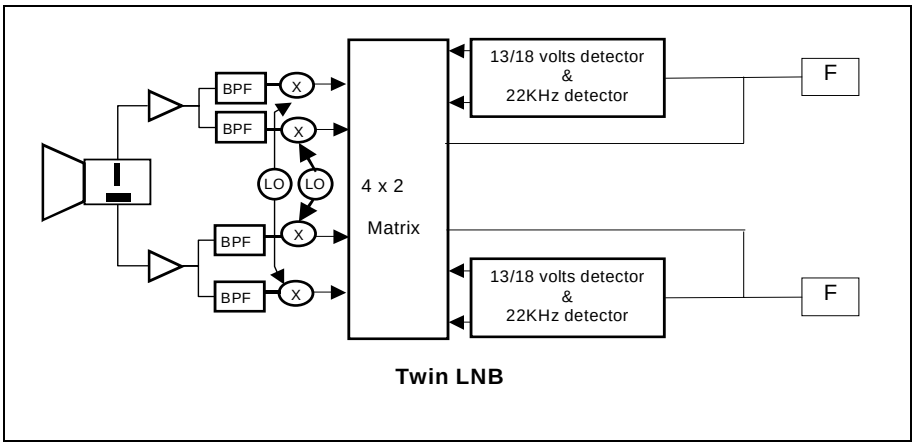
1.1 Description

ST Microelectronics has introduced a new device that targets the LNB, multi-switch and SMATV market. This device, called SaTCR-1 (Satellite Channel Router), is able to translate a transponder to any location in the satellite bandwidth (950-2150 MHz). Multiple SaTCR devices coupled with band-pass filters and RF matrix allow to combine transponders from different polarizations and bands on a single coaxial cable.

The purpose of this document is to describe the AN2056 protocol extension used to control a LNB based on SCR technology.

1.2 Standard LNB versus SaTCR LNB

A Ku-band satellite can provide up to 4.1 GHz of useful bandwidth (2 polarizations x (12750 MHz -10700 MHz)). A standard DVB-S tuner can receive frequencies from 950 MHz to 2150 MHz which means slightly more than 1 GHz bandwidth.

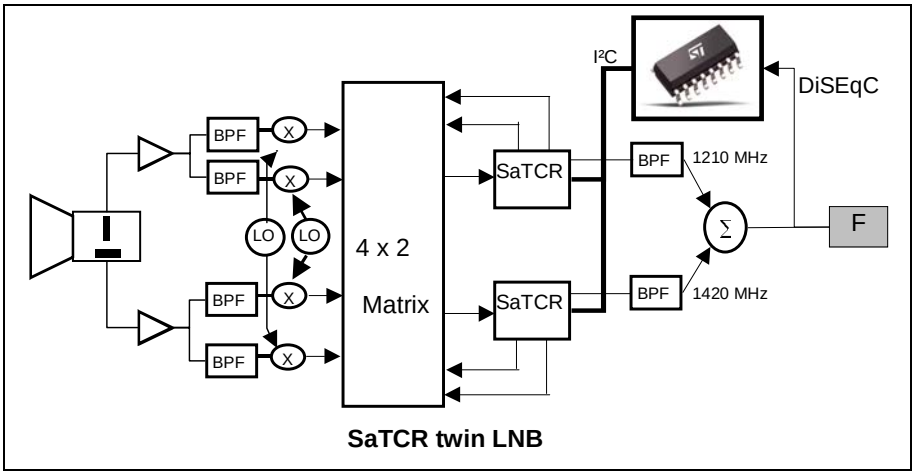


Twin LNB

To be able to receive all the available channels in the Ku-band using a conventional LNB, a set-top box has to select the polarization and the local oscillator corresponding to the desired transponder. The polarization is selected by changing the voltage of the LNB supply (13 volts for vertical polarization, 18 volts for horizontal polarization). The local oscillator is selected by adding or not a 22 KHz tone on the LNB supply (when 22 KHz in on the highest LO is selected). Local oscillator frequency can be 9750 MHz or 10600 MHz depending on the location of the transponder. If the respective transponder is in the lower part of the spectrum (<11700 MHz) the 9750 MHz LO is selected, otherwise 10600 MHz LO is selected. The tuner has to be set to the correct frequency using the following formula:

$$F_{tuner} = F_{transponder} - F_{LO}$$

With a LNB integrating SaTCR-1 devices, the transponder selection (polarization, LO selection and frequency translation) is done through a single DiSEqC command named ***ODU_ChannelChange*** (see Section 3.2.1 on page 8)



SaTCR twin LNB

First stage of a SaTCR LNB (up to the matrix) is similar to a conventional LNB. As a consequence, the transponder frequency at the input of a SaTCR device is the same as Ftuner with a classical LNB:

$$F_{satcr\_input} = F_{transponder} - F_{LO}$$

Then, the SaTCR device should translate the transponder inside the bandwidth of its associated band pass filter. To perform that operation, the SaTCR VCO has to be set according to the following formula:

$$F_{satcr\_vco} = F_{satcr\_input} + F_{bpf} = |F_{transponder} - F_{LO}| + F_{bpf}$$

In addition, SaTCR LNB includes new features that allow auto-detection of its parameters.

1.3 What does this mean for the set-top box?

1.3.1 Setup

The control of a SaTCR LNB requires more parameters than a standard LNB. Those parameters can be entered manually by the user or automatically detected by the set-top box. Automatic setup is recommended for all set-top boxes including tone detection capabilities (see Section 2.1 on page 5).

1.3.1.1 Manual

In this mode, the set-top box should display an LNB setup screen where the user should enter the following parameters:

–• LNB type: the type of LNB used (see Table 3 on page 11 for SaTCR LNB application type)

–• Local Oscillator frequencies: depending on the LNB type, 1 or 2 frequencies should be entered

–• SaTCR band-pass filters frequencies: depending on the SaTCR application type, up to 8 frequencies should be entered.

1.3.1.2 Automatic

In that mode, the set-top box LNB setup screen should contain a button that launches the LNB auto-detection procedure (see Subsection 2.2: *Detecting LNB parameters* on page 5) using ***ODU_SCRxSignalON***, ***ODU_Config*** and ***ODU_LOFREQ*** DiSEqC commands.

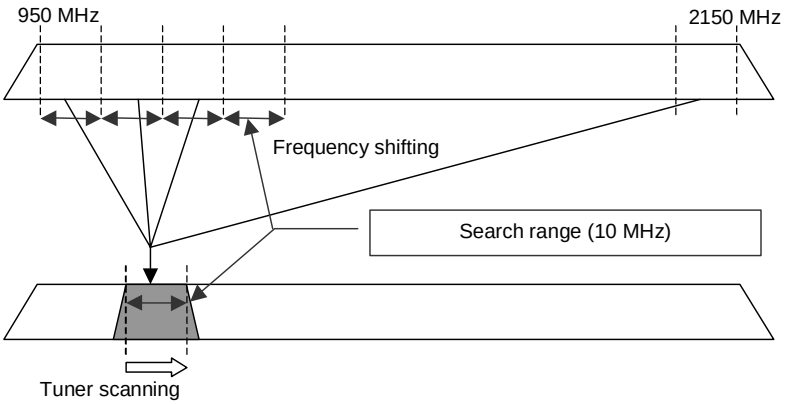
1.3.2 Tuning to a known transponder

Tuning to a known transponder is done by sending ***ODU_ChannelChange*** DiSEqC command (to select the polarization, the local oscillator and to perform frequency shifting) and tuning to the shifted frequency.

This procedure is described more in detail in Subsection 2.3: *Searching for a channel* on page 7.

1.3.3 Scanning a complete satellite

Bandpass filter located in the LNB has limited bandwidth and this bandwidth can change from one application to another. In consequence, the most secure solution to scan the complete satellite is to split the bandwidth into small sections (typically 10 MHz), to shift them using ***ODU_ChannelChange*** DiSEqC command, and to scan them using the tuner as described below:



Satellite scanning

1.3.4 Standby mode

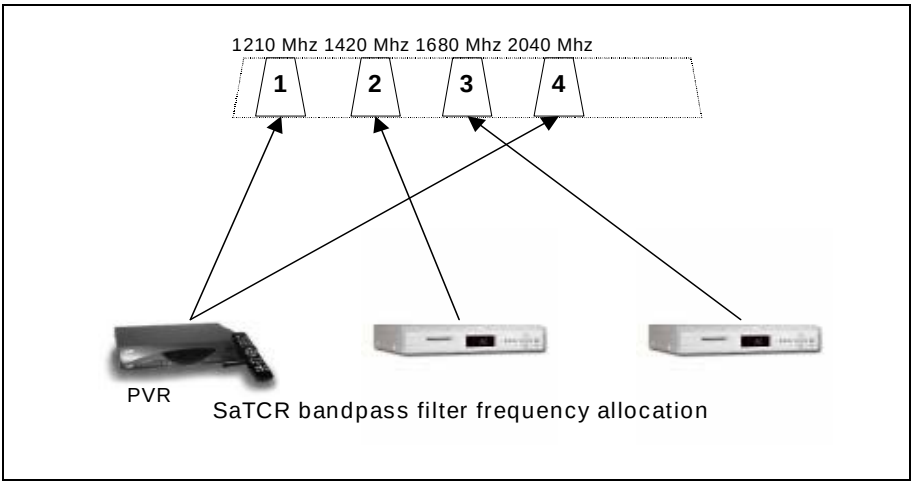
When the set-top box enters in standby mode or (in case of PVR boxes) when a tuner is not in use, its associated SaTCR should be set in power-saving mode using ***ODU_Power_OFF*** DiSEqC command.

1.4 How to manage multiple set-top boxes?

When using several set-top boxes connected to the same cable, the following items should be taken into account.

1.4.1 SaTCR allocation

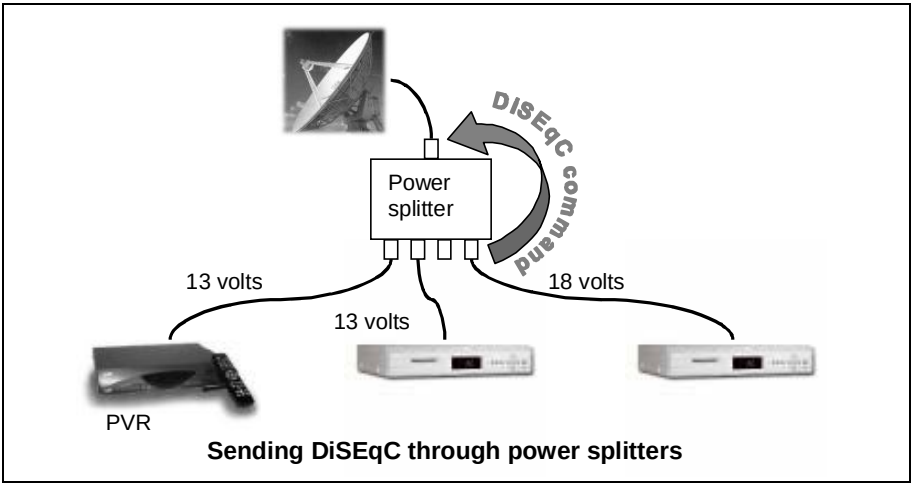
In order to avoid having two set-top boxes or two tuners of the same set-top box trying to use the same SaTCR, each set-top box tuner should be allocated a dedicated SaTCR. In consequence, the LNB setup screen will display all SaTCR band-pass filters frequencies and the user will select one, two or more of them depending if the set-top box is a standard one (single tuner), a PVR (dual tuner) or multi-tuner box. When installing other set-top boxes, the user will have to take care not using an already allocated SaTCR device.



SaTCR bandpass filter frequency allocation

1.4.2 DiSEqC & power splitters

DiSEqC commands should always be sent above a 18 volts DC (see Subsection 3.1: *SaTCR DiSEqC frames* on page 8) in order to ensure proper connection to the LNB when set-top boxes are connected using power splitters.



Sending DiSEqC through power splitters

2 Description of the software architecture

This chapter describes in detail the software routines that should be implemented inside the STB to support SaTCR LNB.

The basic commands need a standard DiSEqC 1 HW only. This ensures compatibility with most of today deployed boxes. Set-up is done in a manual mode as in today's boxes. An innovative approach using an RF tone as back channel communication allows a bidirectional communication between the STB and the SaTCR LNB whilst keeping compatibility with DiSEqC 1. Set-top boxes featuring DiSEqC 2 can profit from the bidirectional communication of the DiSEqC 2 protocol as

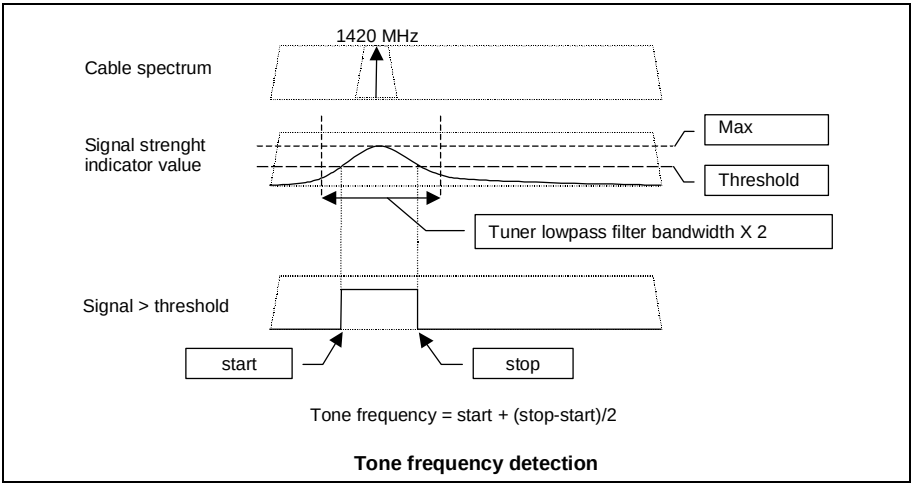
an alternative. The STB sends requests using the DiSEqC protocol (see Chapter 3 on page 8) and the SaTCR LNB answers using RF tones. SaTCR answers are binary. If the tone is located exactly at the center of the band-pass filter, the answer is TRUE. If the tone is located 24 MHz higher than the band-pass filter frequency, the answer is FALSE.

2.1 Performing tone frequency detection

The purpose of this routine is to use the signal strength indicator available on any STB to perform auto detection of the tones generated by the SaTCR LNB.

This routine assumes that the scanned bandwidth contains only tones and no QPSK or analog carriers. This condition is naturally guaranteed by the operation of the SaTCR LNB.

In a first time, the bandwidth is scanned with the tuner. For each tuner step the signal strength (linked to the AGC control level) should be read from the demodulator device and stored in an array. When the complete bandwidth has been scanned, the maximum signal strength value is calculated. This value allows to calculate the threshold value used to find rising and falling edges of the tone. The tone frequency is located in the middle of the segment delimited by rising (start) and falling (stop) edges.



Tone frequency detection

In order to have an accurate estimation of the tone frequency, the scan step should be as small as possible (1 MHz gives a good accuracy). Rising and falling edge frequencies depend on the tuner low-pass filter bandwidth, the smaller this filter bandwidth is the closer will be the edges from the tone frequency. The tuner filter bandwidth should be greater than tuner step divided by two, to avoid unscanned zones. To be able to make the difference between two consecutive tones, the tuner low-pass filter bandwidth should be less than the minimum distance between the two tones divided by two. In case of SaTCR applications, for implementing a proper process of the tone detection, tuner low-pass filter bandwidth should be less than 50 MHz. By convention, the tone frequency is generated at frequency integer multiple of 2 MHz.

In summary:

–• Tuner step as small as possible

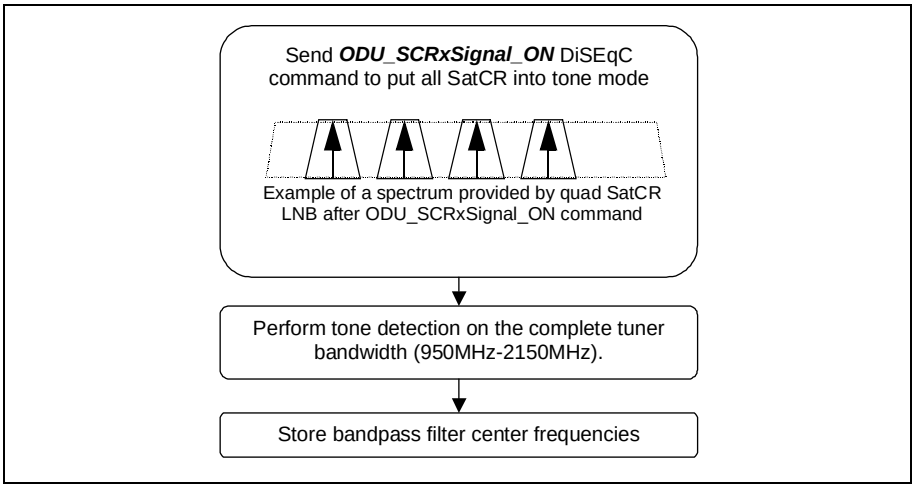
–• (Tuner step / 2) < low-pass filter bandwidth < 50 MHz

2.2 Detecting LNB parameters

To be able to setup a bidirectional communication it is mandatory to know at least one band-pass filter center frequency. In consequence, the band-pass filter center frequency detection should be done before application type and LO frequencies detection.

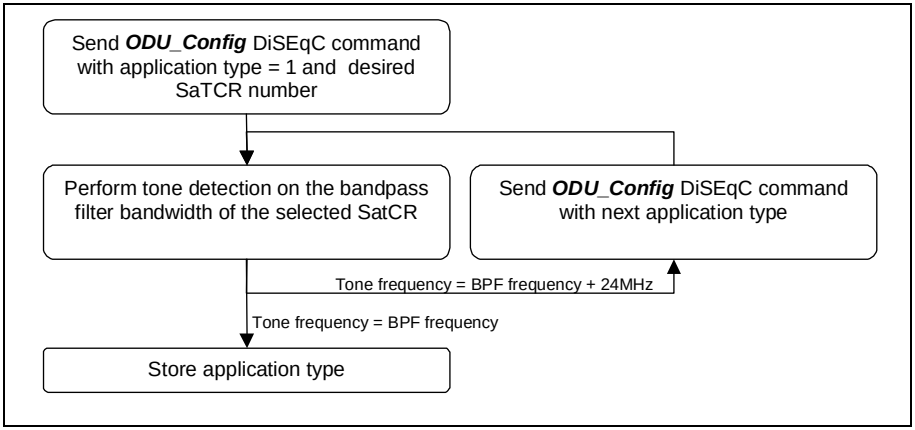
2.2.1 Band-pass filters center frequencies

The purpose of this routine is to detect all band-pass filters center frequencies.


Send ODU_SCRxSignal_ON DiSEqC command to put all SatCR into tone mode
Example of a spectrum provided by quad SatCR LNB after ODU_SCRxSignal_ON command
Perform tone detection on the complete tuner bandwidth (950MHz-2150MHz).
Store bandpass filter center frequencies

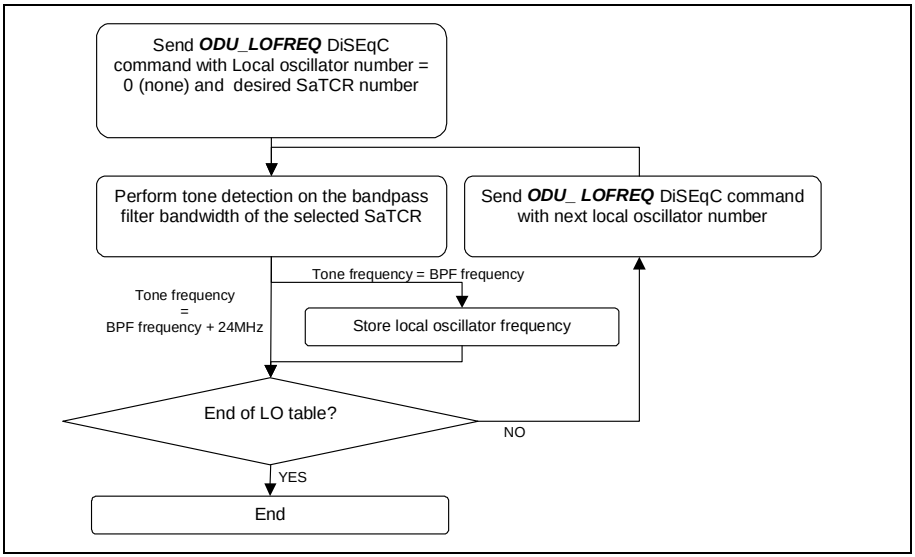
2.2.2 Application type

The purpose of this routine is to recognize the type of SaTCR LNB connected to the STB.


Send ODU_Config DiSEqC command with application type = 1 and desired SaTCR number
Perform tone detection on the bandpass filter bandwidth of the selected SatCR
Send ODU_Config DiSEqC command with next application type
Tone frequency = BPF frequency + 24MHz
Tone frequency = BPF frequency
Store application type

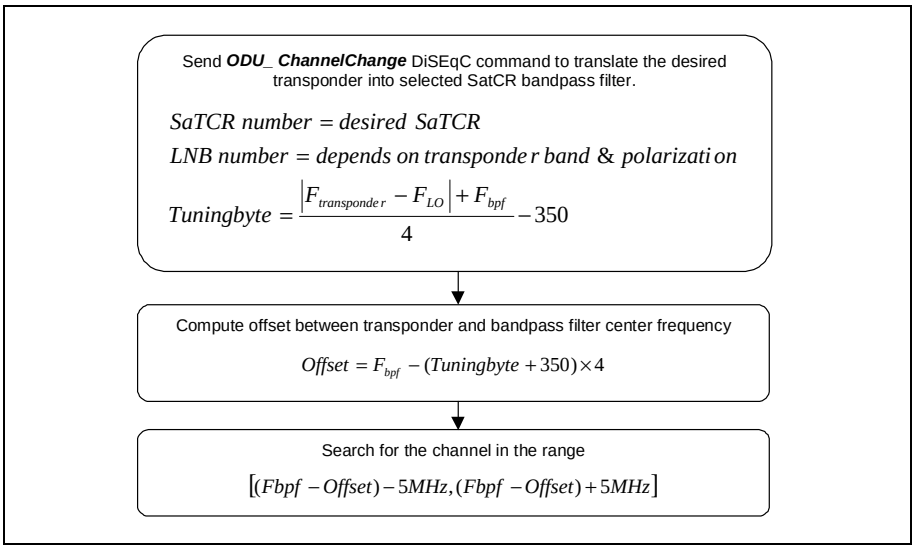
2.2.3 LO frequencies

The purpose of this routine is to detect SaTCR LNB local oscillators frequencies.


Send ODU_LOFREQ DiSEqC command with Local oscillator number = 0 (none) and desired SaTCR number
Perform tone detection on the bandpass filter bandwidth of the selected SaTCR
Send ODU_ LOFREQ DiSEqC command with next local oscillator number
Tone frequency = BPF frequency
Tone frequency = BPF frequency + 24MHz
Store local oscillator frequency
End of LO table?
NO
YES
End

2.3 Searching for a channel

The purpose of this routine is to lock on a satellite transponder using SaTCR LNB.


Send ODU_ ChannelChange DiSEqC command to translate the desired transponder into selected SatCR bandpass filter.
SaTCR number = desired SaTCR
LNB number = depends on transponder band & polarization
Tuningbyte = (|F_transponder − F_LO| + F_bpf)/4 − 350
Compute offset between transponder and bandpass filter center frequency
Offset = F_bpf − (Tuningbyte + 350) × 4
Search for the channel in the range
[(Fbpf − Offset) − 5MHz, (Fbpf − Offset) + 5MHz]

2.4 Power saving

The purpose of this routine is to turn off unused SaTCR devices.

Send ***ODU_ PowerOFF*** DiSEqC command to switch off desired SatCR.

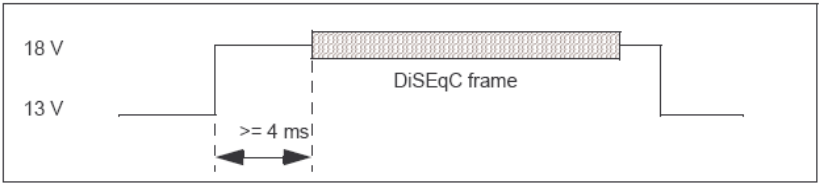
3 DiSEqC commands

This chapter describes the SaTCR LNB DiSEqC commands. The commands have been defined in a way to be fully compatible with the existing DiSEqC 1 protocol.

The basic (unidirectional) LNB control is possible with only two commands (ODU_Channel_Change, ODU_PowerOff), whereas some additional (bi-directional) commands (ODU_SCRxSignalOn, ODU_Config, ODU_Lofreq) allow for sophisticated automatic installation routines using the above described RF tone approach.

3.1 SaTCR DiSEqC frames

DiSEqC protocol used by SaTCR LNBs is the same as conventional DiSEqC 1 except that commands have to be sent above a 18 volts DC instead of 13 volts DC (see §1.4.2????). The delay between 13 to 18 volts switching and the beginning of a DiSEqC frame should be more than 4 ms.



DiSEqC frame requires 5 bytes:

Framing	Address	Command	Data1	Data2
E0	10/11	5A/5B	XX	XX

3.2 Mandatory DiSEqC commands

This is the minimum set of commands that should be implemented in a set-top box in order to control SaTCR LNB. All of them use the DiSEqC command **5A** (hex).

3.2.1 ODU_ChannelChange

E0 10 5A channel_byte1 channel_byte2

Allows to select which LNB feed is routed on a SaTCR device and to program the SaTCR frequency.

channel_byte1							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
SaTCR number (Table 1)			LNB number (Table 2)			T[9:8]	

channel_byte2							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
T[7:0]							

T is the tuning byte used to program SaTCR VCO frequency. In order to limit the number of transmitter bits to 10 a constant value (350) is substracted. The transmitted tuning byte can be computed using the following formula:

$$T = \frac{Fvco}{4} - 350$$

Example:

–Fvco = 4300 MHz ⌊ T=(4300/4) - 350 =725 (dec) ⌊ 2D5 (hex)

–Fvco = 3100 MHz ⌊ T=(3100/4) - 350 =425 (dec) ⌊ 1A9 (hex)

–Fvco = 1900 MHz ⌊ T=(1900/4) - 350 =125 (dec) ⌊ 7D (hex)

Table 1.

SaTCR	number
SaTCR1	0
SaTCR2	1
SaTCR3	2
SaTCR4	3
SaTCR5	4
SaTCR6	5
SaTCR7	6
SaTCR8	7

By convention, the SaTCR1 is allocated the lowest IF frequency, the SaTCR2 is allocated the second and so forth.

Table 2.

Satellite	LNB	number
Position A	Low band / vertical polarization	0
	High band / vertical polarization	1
	Low band /horizontal polarization	2
	High band / horizontal polarization	3
Position B	Low band / vertical polarization	4
	High band / vertical polarization	5
	Low band /horizontal polarization	6
	High band / horizontal polarization	7

3.2.2 ODU_PowerOFF

E0 10 5A poweroff_byte 00

Puts the selected SaTCR device into low-power mode

poweroff_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
SaTCR number (see Table 1)			0	0	0	0	0

3.3 Optional DiSEqC commands

This set of commands associated with the tone detection algorithm allows set-top boxes to perform auto-detection of SaTCR LNB parameters. All of them use the DiSEqC command **5B** (hex) which gives access up to 32 sub-functions. The following table describes the sub-function mapping:

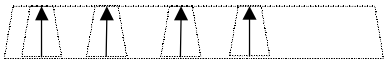
Sub-function	number
ODU_SCRxSignal_ON	00h
ODU_Config	01h
ODU_LoFreq	02h
Not allocated	03h..1Fh

3.3.1 ODU_SCRxSignal_ON

E0 10 5B subfunction_byte 00

Each SaTCR generates a tone at the center frequency of its associated band-pass filter.

subfunction_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
SaTCR number = 0			Sub function = 0				



Example of a spectrum provided by quad SaTCR LNB
after ODU_SCRxSignal_ON command

3.3.2 ODU_Config

E0 10 5B subfunction_byte config_byte

Allows to check the application number. A tone is generated at the center frequency of the band-pass filter of the selected SaTCR if application number is ok otherwise the tone is 24MHz higher.

subfunction_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
SaTCR number (see Table 1)			Sub function = 1				

config_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 2	Bit 0
Application number (see Table 3)							

Table 3.

Application	number
Not allocated	00h
Single SaTCR & Legacy	01h
Twin SaTCR (Standard band RF)	02h
Twin SaTCR & legacy (Standard band RF)	03h
Quad SaTCR (Standard band RF)	04h
Double twin SaTCR (Standard band RF)	05h
Twin SaTCR (Wide band RF)	06h
Twin SaTCR & legacy (Wide band RF)	07h
Not allocated	08h..0Fh
Reserved for operator	10h..1Fh
Reserved for operator	20h..2Fh
Not allocated	30h..FFh

Note:

1. •*Legacy: conventional output signal structure, fully occupied bandwidth from 950 MHz to 2150 MHz. In application 03h and 07h, the legacy signal is delivered on a separated F connector of the LNB. Application 01h is a proprietary system, in which the "legacy" term corresponds to a specific signal structure.*
2. •*Standard band RF: The signal delivered to each SaTCR has 1.2 GHz of bandwidth (11700-9750 or 12750-10600).*
3. •*Wide band RF: The signal delivered to each SaTCR comes in a 2.05 Ghz bandwidth.*

3.3.3 ODU_LOFREQ

E0 10 5B subfunction_byte lofreq_byte

Allows to check LNB local oscillator frequencies. A tone is generated at the center frequency of the band-pass filter of the selected SCR if local oscillator is ok otherwise the tone is 24MHz higher.

subfunction_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
SaTCR number (Table 1)			Sub function = 2				

lofreq_byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Local oscillator number(see Table 4)(see Table 5)							

Table 4.

Local oscillator frequency	Number (hexadecimal)
None (switcher)	00h
Unknown	01h
9750 MHz	02h
10000 MHz	03h
10600 MHz	04h
10750 MHz	05h
11000 MHz	06h

Table 4.

Local oscillator frequency	Number (hexadecimal)
11250 MHz	07h
11475 MHz	08h
20250 MHz	09h
5150 MHz	0Ah
1585 MHz	0Bh
13850 MHz	0Ch
Not allocated	0Dh.. 0Fh
Wide band LUT (see Table 5)	10h.. 1Fh
Not allocated	20h.. FFh

Table 5.

Local oscillator frequency	Number (hexadecimal)
None (switcher)	10h
Unknown	11h
13250 MHz	12h
Not allocated	13h.. 1Fh

4 Revision history

Table 6. Revision history

Date	Revision	Description of changes
05 October 2004	1	First issue

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